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Light, Energy and the Environment, 2018: introduction to the joint feature issue

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Abstract: This joint feature issue of *Optics Express* and *Applied Optics* highlights contributions from authors who presented their latest research at the OSA Light, Energy and the Environment Congress, held in Sentosa Island, Singapore from 5 to 8 November 2018. The joint feature issue comprises 11 contributed papers, which expand upon their respective conference proceedings. The published papers introduced here cover a broad range of timely research topics in optics and photonics for lighting and illumination, solar energy, hyperspectral imaging, and environmental sensing.

1. Introduction

The OSA Light, Energy and the Environment Congress [1], held in Sentosa Island, Singapore, brought together researchers with expertise across several related areas in optics and photonics. Specifically, the co-located OSA topical meetings were: Fourier Transform Spectroscopy (FTS), Hyperspectral Imaging and Sounding of the Environment (HISE), Optics and Photonics for Energy & the Environment (E2), Optics for Solar Energy (SOLAR), and Solid-state Lighting (SSL). The conference program included a diverse group of keynote, invited, and contributed speakers from around the world who discussed current research trends at the intersection of light, energy, and the environment.

As in previous years [2–5], the OSA supported a feature issue to follow the Light, Energy and the Environment (LEE) Congress. New for this year is the joint feature issue, a collaboration between *Optics Express* and *Applied Optics*. This format allowed additional publication options for congress participants to expand upon their presented works. The joint feature issue comprises 11 total publications, with 9 papers published in *Optics Express* and 2 papers published in *Applied Optics*. In the following sections, we introduce each paper and provide context for how they fit within the broader LEE Congress themes.

2. Lighting and Illumination

Smart lighting and projection systems offer significant energy savings and illumination flexibility in sensitive indoor environments such as museums and art galleries. Dormus and Davis [6] report a study of one such smart lighting system, designed to reduce surface absorption on a series of test objects. By leveraging controllable solid-state lighting, future smart lighting systems may readily adapt to their surroundings and thus improve perception and maintain quality in delicate situations. Smart lighting systems can also include light-

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actuated optics. Wang et al. [7] report temperature changes on a moveable lens group at the focus of a light beam which resulted in driven mechanical motion using shape memory alloy. Applying smart materials could enable beam steering without electrical power, resulting in less energy-consuming optics and photonics systems.

3. Solar energy

Passive emitter and rear cell (PERC) silicon solar cells are an increasingly viable solar cell technology amenable to mass production. Lai et al. [8] report an optical approach to improving the open-circuit voltage of PERC silicon solar cells by engineering high reflectivity into the rear-side dielectric stack. Such an optical coating has potential to reduce damage to the cell from laser ablation in high-throughput laser machining. Yan et al. [9] also report a new optical coating technology. By applying a double-layer anti-reflection coating to monocrystalline silicon-based *n*-type front and back contact (*n*FAB) solar cells, they report improved collection in the ultraviolet portion of the solar spectrum. Improved efficiency which resulted from the double-layer coating could, in combination with additional advances, further increase the viability of silicon-based solar cells in an already rapidly growing market.

For the first time, Zhou et al. [10] report enhanced radiative cooling in concentrated photovoltaics (CPV), applying a compound radiative cooler to a photovoltaic cell receiving an illumination power greater than 10 suns. The result is a reported relative increase in open-circuit voltage of 5.7%, attributable to a 10 °C reduction in operating temperature. A generalization of this radiative cooling approach should find application not only in a much broader class of PV systems, but could be readily adapted to other optoelectronic systems.

Under very high solar concentrations (>200 suns), photovoltaics are generally attractive because of their high power conversion efficiencies. Cui et al. [11] report silicone optical elements as lightweight, compact, and cost-effective concentrator materials. Silicone materials as passive optical elements in solar concentrating systems can leverage freeform optical design to enhance throughput in a compact apparatus. Finally, to lower costs for emerging solar cell materials, power output must still be further improved. To aid in such efforts, Schmager et al. [12] report a comprehensive modeling framework for energy yield in perovskite-based multi-junction PV. The report focused on simulating over a variety of cell architectures, and should enable rapid optimization under dynamic solar spectrum conditions.

4. Hyperspectral imaging and environmental sensing

Hidden landscapes like ancient ruins and underground mines require simultaneous three-dimensional topography to remotely identify physical structures and rock types. Malkamäki et al. [13] report a portable and field-operable, supercontinuum-based LiDAR instrument capable of producing three-dimensional point clouds comprising spectral data. Included in the paper is a practical discussion of accuracy as it relates to optical design and data processing, which will be a resource to others in the field of multicomponent LiDAR.

Designing optics and photonics for environmental monitoring in complex matrices, like industrial wastewater, presents several challenges, which include ensuring specificity in detection, as well as portability and robustness when in harsh environments. Zhao et al. [14] report a laser-induced breakdown spectrometer (LIBS) and graphite-enrichment apparatus for the identification of heavy metals in wastewater. Improvements in the limits of detection of this and other LIBS instruments will improve their viability and impact for environmental sensing of harmful heavy metals.

The hydroxyl radical (OH) is a major oxidizer within the Earth's atmosphere. By developing a deployable laser-induced fluorescence (LIF) instrument, Wang et al. [15] report measurements of tropospheric OH at ambient number densities approaching 10^5 cm^{-3}. Uniquely, the authors report a portable OH standard to perform field calibrations and improve metrology, thus improving continuity for measurements over days and weeks. Finally, carbon monoxide (CO), hydrogen sulfide (H_2S), and sulfur dioxide (SO_2) are corrosive and potentially poisonous molecular fault diagnostics for electric systems using sulfur hexafluoride (SF_6) dielectric insulating gas. Yin et al. [16] report a multicomponent photoacoustic gas sensor for routine monitoring of these fault indicator compounds, as well as the SF_6 parent gas which otherwise is colorless, odorless, and non-flammable. The three-laser optical system also comprises two-channel differential acoustic detection which serves to both reduce detection noise and realize the multicomponent analysis in a compact apparatus.

5. Outlook: new forums for light, energy and the environment

While the 2018 OSA Light, Energy and the Environment Congress was the last of its kind (for now), the OSA topical meetings formerly co-located therein will continue under one of two new OSA congress umbrellas.

The inaugural OSA Optical Sensors and Sensing Congress [17] will be held in San Jose, California from 25 to 27 June 2019 with topical meetings Fourier Transform Spectroscopy (FTS), Hyperspectral Imaging and Sounding of the Environment (HISE), and Optics and Photonics for Sensing the Environment (ES, formerly E2) joining with the topical meeting Optical Sensors (SENSORS).

The OSA Advanced Photonics Congress [18] will be held in Burlingame, California from 29 July – 1 August 2019 and include the newly formed topical meeting Optical Devices and Materials for Solar Energy and Solid-state Lighting (PVLED) which brings together leading international experts in optical science and technology for solar energy devices and solid-state lighting. Joining PVLED will be co-located meetings Integrated Photonics Research, Silicon, and Nano-Photonics (IPR), Novel Optical Materials and Applications (NOMA), Photonic Networks and Devices (NETWORKS), and Signal Processing in Photonic Communications (SPPCom).

The joint feature issue guest co-editors, along with all the congress and topical meeting co-chairs, would like to thank our numerous committee members as well as the OSA professional staff for their support in creating a fantastic scientific program for OSA Light, Energy and the Environment Congress 2018. We hope to see you all again soon at another OSA Congress.

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Optics EXPRESS

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